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NITROGEN APPLICATION ALLEVIATES THE ADVERSITIES OF WATER STRESS IN WHEAT CULTIVARS

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Water stress is a severe environmental limitation to crop productivity. It induced loss in crop yield probably exceeds losses from all other causes. Nitrogen (N) fertilizer has been found to be effective in reducing the adverse effects of water scarcity. Therefore, a pot experiment was conducted to quantify the amount of nitrogen which has more effective to alleviating the negative effect on different wheat cultivars under various water stress levels. Experiment comprised of four wheat cultivars viz. Inqlab-91, Bhakkar-2002, Fareed-2006 and Shafaq-2006, two irrigation water levels viz. 50% and 100% field capacity and four N levels viz. 0 (control), 50, 100 and 150 kg ha^{-1}. Results of the study revealed that water stress caused the poor crop stands establishment, reduced leaf area, crop growth rate, water relations attributes and yield and yield components of wheat cultivars. Nevertheless, N fertilizer enhanced these contributes and ultimately increase the yield of the wheat crop under water deficit condition. Cultivar Bhakkar-2002 produced maximum grain yield when 100 kg N ha^{-1} was applied at 50% field capacity that is 36% more yield than control (0 kg ha^{-1}). Under well watered condition (100% field capacity) maximum grain yield was recorded in cultivar Shafaq-2006 when 150 kg N ha^{-1} was applied. According to the results of experiment, it is concluded that N applied at rate 100 kg ha^{-1} could ameliorate negative effects of on wheat grown under water stress condition.

Keywords: Water stress, nitrogen fertilizer, wheat cultivars, yield and yield components.

INTRODUCTION

Production of wheat in arid and semi-arid regions is limited due to deficiencies of water and nitrogen in soil. Shortage of irrigation water in these areas is one of the most important factors causing the low productivity. The yield of the wheat is greatly reduced under water deficit condition (Ashraf *et al*., 1994; Van Oosterom *et al*., 1995). Water stress caused more losses than other constraints which also depend upon severity and duration of the stress (Farooq *et al*., 2008). It reduces crop growth rate (CGR) and yield regardless of the growth stage at which it occurs in crops (Jensen and Mogenson 1984). Under water stress, cell elongation of crop plants can be inhibited by disruption of water movement from the xylem to elongating cells (Nonami, 1998). Impaired mitosis, cell elongation and expansion result in decreased crop growth, plant height and leaf area under water deficit condition (Nonami, 1998; Kaya *et al*., 2006). Water stress disturbs the plant water relations, photosynthesis, assimilate translocation and economic yield in crops (Siddique *et al*., 2000; Atteya, 2003; Farooq *et al*., 2008; Hussain *et al*., 2008). Addition of nitrogen (N) fertilizer to wheat is required to ensure that N is available throughout the growing season due to its important role in promoting both vegetative and reproductive growth. High yielding wheat cultivars require large and regular supply of N to develop high photosynthetic capacity and maintain the proper nitrogen concentration in the leaves so that CO2 assimilation is not affected when large rates are required for ear growth and grain-filling period (Lawlor, 1995). Grain development is a function of rate and duration of grain growth, determined by photosynthates supply and is affected by a number of environmental factors including water and nitrogen.

Nitrogen fertilizer is known to alleviate the adverse effects of water stress on the crop growth (Marschner, 1995; Payne *et al.* 1995; Raun and Johnson, 1999). Halvorson and Reule (1994) reported that yield of wheat crop increased under water deficit condition with increasing the dose of nitrogen. In a winter wheat it was observed that the grain yield increased at low dose of nitrogen supply, while high dose of nitrogen fertilizer proved to be detrimental under mild water deficit condition (Nielsen and Halvorson, 1991). It is reported that additional dose of nitrogen does not play positive role in alleviating the adverse effect of water stress on plant growth (Ashraf *et al*., 2001).

Prolonged period of water deficit condition severely restrict the mobility of nitrogen through dehydrated soil, and thus co-occurrence of water deficits and nitrogen limitations are common in most of soils. Although the physiological responses of plants to either water or nitrogen stress have been widely investigated. An importance of nitrogen

fertilizer in increasing wheat production has been well known, but still it is difficult to find out the quantities to apply under water deficit condition. This is due partially to lack of information on nitrogen uptake and movement among plant parts under these conditions. Therefore, this study was conducted to quantify the amount of nitrogen which gives the best result on different wheat cultivars under water deficit condition and also determined the effects on growth and yield of wheat under water deficit condition. To identify the most suitable cultivar under water and nitrogen stress.

MATERIALS AND METHODS

A pot study to determine the effect of different nitrogen levels on germination, growth and yield of wheat varieties under water deficit condition was conducted at Green House, Department of Agronomy, University of Agriculture Faisalabad (latitude 31°30 N, longitude 73°10 E and altitude 213 m).

***Experimental detail*:** Seeds of wheat cultivars were obtained from Ayub Agriculture Research Institute (AARI) Faisalabad. The experiment was laid out in Completely Randomized Design (CRD) with factorial arrangements having four replications. Same size of plastic pots was filled with sandy clay loam soil of equal weights (10 kg). These pots were then divided into two groups, each representing a specific water stress treatment (50% and 100% field capacity). Soil in each pot was completely saturated with normal irrigation water. When the moisture contents were at field capacity, seeds of the four wheat cultivars were sown with hand on 2nd week of November. After the germination 5 plants were maintained in each pot. Soil analysis was carried out in Soil fertility laboratory, Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad. Soil was sandy clay loam contained total nitrogen contents 61%, phosphorus 7.95 mg L^{-1} and organic matter 0.99 %. The water stress treatments (50% and 100% field capacity) were applied after sowing of seeds in pots. Water stress treatments were maintained on gravimetric basis (Nachabe, 1998). Moisture contents of pots were maintained and regularly monitored by taking the soil sample and determined the moisture contents and calculated for 50% and 100% field capacity through addition of normal irrigation water if required on daily basis till the maturation of the crop.

***Observations*:** Number of emerged seeds was recorded daily according to the seedling evaluation handbook of the Association of Official Seed Analysis (AOSA) (1983). Time to 50% emergence was expressed as time taken for half of the seeds to germinate. The time to get 50% emergence was calculated according to the following formula of Coolbear *et al.* (1984) modified by Farooq *et al*. (2005):

$$E_{50} = t_i + \left[\frac{N/2 - n_i}{n_j - n_i}\right](t_j - t_i)$$

where N is the final emergence counts, and ni and nj are cumulative number of seeds emerged by adjacent count at time t_i and t_j when ni < N/2 > nj.

Mean emergence time (MET) was calculated according to the equation of Ellis & Roberts (1981):

$$MET = \sum(Dn) \Big/ \sum n$$

Where n is the number of seeds which emerged on day D, and D is the number of days counted from the beginning of emergence

Final emergence percentage was calculated after completion of germination:

Final emergence percentage = Total number of emerged plants/total number of plants sown ×100

At harvest, all yield and yield parameters were examined following standard procedure. From start of physiological maturity, the emergence of leaves was recorded throughout the experiment, growth traits were examined five times during growth season at 15-days interval, leaf area was calculated using the plant samples taken from randomly selected plants from each pot. Leaves were removed and measured the leaf area.

Yield components and characteristics of spike were recorded at maturity. Crop was harvested when fully ripened to determine grain and biological yield and harvest index (HI).

***Statistical Analysis*:** Data collected on all parameters were analyzed statistically by using Fisher's analysis of variance technique and least significantly difference (LSD) test at 5% probability level was applied to compare the treatments' means (Steel *et al.*, 1997).

RESULTS

Wheat cultivars (Inqlab-91, Bhakar-2002, Fareed-2006 and Shafaq-2006) were subjected to varied nitrogen levels (0, 50, 100 and 150 kg ha^{-1}) under field capacity (FC) of 50 and 100%. Table 1A depicts the response of wheat cultivars to varied nitrogen levels and field capacity levels in terms of emergence parameters. With 50% field capacity, all cultivars maintained maximum time to 50% emergence (E_{50}) as compared to 100% FC. At 50% FC, nitrogen application reduced E_{50} as compared to control but the response of different nitrogen concentration was at par in Inqilab-91. Bhakkar-2002 cultivar responded to nitrogen application by showing more E_{50} with 50 and 100 kg ha^{-1} nitrogen levels with minimum at 150 kg ha^{-1} nitrogen application. At 50% FC, Fareed-2006 and Shafaq-2006 maintained less E_{50} with 150 kg ha^{-1} nitrogen. Among all four tested wheat cultivars, Shafaq-2006 maintained less time to 50% emergence under stressed conditions (50% FC). Mean emergence time (MET) remained non-significant in Inqlab-91, Bhakar-2002, Fareed-2006 at both FC levels with different nitrogen level

supplementation. The MET increased in Shafaq-2006 at 50% FC as compared to 100% FC, being minimum at 150 kg ha^{-1} nitrogen level, when compared with other nitrogen levels under stressed conditions. In case of emergence energy (EE), the cultivar Inqlab-91 showed at par response at different nitrogen level at 50% FC, however, it was maximum at nitrogen level (100 kg ha^{-1}) at 100% FC. The cultivars Bhakar-2002 and Fareed-2006 maintained higher EE at 150 kg ha^{-1}at 50% FC as compared to other applied nitrogen levels. Shafaq-2006 also gave at par response of EE at 100 and 150 kg ha^{-1} nitrogen level in water stressed conditions. Water stressed conditions reduced final emergence percentage (FEP) of all the cultivars. It was maximum in all cultivars with addition of 150 kg ha^{-1} nitrogen when compared under stressed conditions. 100 kg ha^{-1} nitrogen level also showed at par response except for Bhakkar-2002.

The nitrogen levels applied at 50 and 100% FC levels, improved the relative water contents (RWC) of all the tested wheat cultivars. Maximum RWC were maintained at 100% FC, however, at 50% FC in all the cultivars, higher dose of nitrogen (150 kg ha^{-1}) surpassed all the applied nitrogen levels. Water stress reduced plant height in all the tested wheat cultivars. Under stressed conditions of 50% FC, application of higher dose of nitrogen (150 kg ha^{-1}) improved the plant height in all the wheat cultivars. Shafaq-2006 and Inqlab-91 proved to be more responsive to higher nitrogen level under stressed conditions in terms of plant height. The same nitrogen rate enhanced spike length, grain/spike and 1000 grain weight under stressed conditions, being more prominent response in Bhakar-2002 as compared to other tested cultivars. The response of listed attributes was at par with 100 kg ha^{-1} nitrogen application, except for grain/spike and 1000 grain weight in Shafaq-2006. Shafaq-2006 maintained maximum spikelet/spike and biological yield at 150 kg ha^{-1} nitrogen level at 50% FC. However, in respect of grain yield, Bhakar-2002 maintained higher rank at nitrogen application rate of 100 kg ha^{-1}.

Table 1A: Effect of nitrogen and water stress levels on stand establishment of cultivar Inqlab-91

Nitrogen levels (kg ha^{-1})	**E-50 (days)**		**Mean emergence time (days)**		**Emergence energy (%)**		**Final emergence percentage (%)**	
	50%	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**
Control	8.12a	6.18a	9.14a	9.19a	0.00a	0.00c	41.25c	45.75c
50	6.92b	5.44b	8.94ab	8.54b	0.00a	0.00c	44.25b	46.25c
100	6.81b	5.31b	8.64b	8.44b	0.00a	2.75a	47.54a	47.00b
150	6.49b	5.06b	8.06b	8.50b	0.00a	0.34b	48.50a	57.00a
Means	**7.08A**	**5.49B**	**8.69^{ns}**	**8.66^{ns}**	**0.00B**	**0.77A**	**45.38B**	**49.00A**

Table 1B: Effect of nitrogen and water stress levels on stand establishment of cultivar Bhakar-2002

Nitrogen levels (kg ha^{-1})	**E-50 (days)**		**Mean emergence time (days)**		**Emergence energy (%)**		**Final emergence percentage (%)**	
	50%	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**
Control	6.69ab	6.18a	9.19a	8.69a	0.00b	2.75c	41.50c	50.00c
50	6.92a	5.44b	8.59b	8.77a	0.00b	5.50b	43.50c	61.50b
100	6.81a	5.31b	8.05c	8.70a	0.00b	8.25a	55.75b	61.50b
150	6.49b	5.06b	8.02c	8.49b	5.50a	8.28a	58.75a	69.75a
Means	**6.72A**	**5.49B**	**8.46^{ns}**	**8.66^{ns}**	**1.37B**	**6.19A**	**49.87B**	**60.68A**

Table 1C: Effect of nitrogen and water stress levels on stand establishment of cultivar Fareed-2006

Nitrogen levels (kg ha^{-1})	**E-50 (days)**		**Mean emergence time (days)**		**Emergence energy (%)**		**Final emergence percentage (%)**	
	50%	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**
Control	7.25a	5.12a	9.37a	9.00a	0.00b	0.00b	44.50c	58.50d
50	6.31b	4.14b	9.22a	8.63b	0.00b	0.00b	55.55b	75.25c
100	6.08b	3.75c	8.33b	8.66b	0.00b	2.75a	61.75a	69.75b
150	5.58c	3.56c	8.54b	8.62b	2.75a	2.75a	66.75a	83.50a
Means	**6.30A**	**4.14B**	**8.86^{ns}**	**8.72^{ns}**	**0.68B**	**1.37A**	**57.12B**	**71.75A**

Table 1D: Effect of nitrogen and water stress levels on stand establishment of cultivar Shafaq-2006

Nitrogen levels (kg ha^{-1})	**E-50 (days)**		**Mean emergence time (days)**		**Emergence energy (%)**		**Final emergence percentage (%)**	
	50%	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**
Control	6.36a	3.04b	9.08a	8.62a	0.00b	0.00d	51.25c	69.75c
50	6.22a	3.56a	8.81ab	8.65a	0.00b	8.25c	62.50b	78.00ab
100	5.87a	3.12b	8.87ab	8.60a	2.75a	11.00b	70.75a	83.50a
150	4.19b	3.12b	8.52b	8.34b	2.75a	16.50a	70.50a	89.00a
Means	**5.66A**	**3.21B**	**8.82A**	**8.55B**	**1.37B**	**8.93A**	**63.75B**	**80.06A**

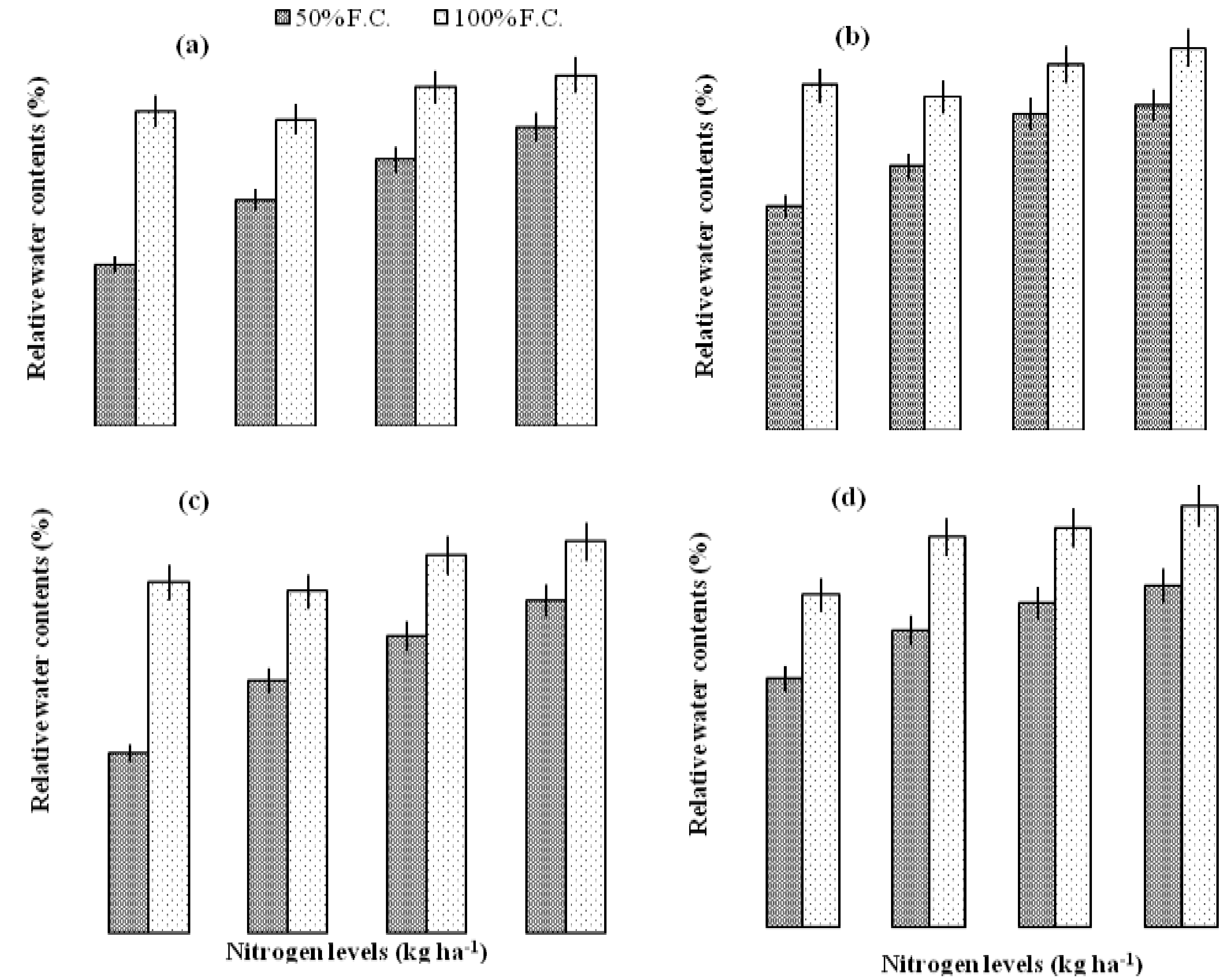

Figure I: Effect of nitrogen and water stress levels on relative water contents of cultivar Inqlab-91 (a), Bhakar-2002 (b), Fareed-2006 (c) and Shafaq-2006 (d)

Table 2A: Effect of nitrogen and water stress levels on yield and yield components of cultivar Inqlab-91

N levels (kg ha^{-1})	Plant height (cm)		Spike length (cm)		Spikelets/ spike		Grains/ spike		1000-grain weight (g)		Biological yield (g/ plant)		Grain yield (g/ plant)	
	50%	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**
Control	58.66c	83.33c	5.20c	6.95d	14.37c	17.55d	33.59c	44.72d	32.19c	35.06c	6.64c	10.65c	2.51c	4.16c
50	71.66b	89.33bc	5.84b	7.43c	15.74b	18.93bc	36.52b	46.08c	36.17b	37.33b	7.71b	14.34b	3.38b	6.11b
100	77.00ab	97.00ab	6.15a	7.94b	16.1lab	19.46b	40.65a	49.67ab	37.42ab	38.28b	11.41a	14.66ab	4.11a	6.67b
150	80.00a	98.33a	6.24a	8.47a	16.88a	21.51a	41.78a	50.07a	38.47a	40.21a	11.28a	15.42a	4.30a	7.02ab
Means	**71.83B**	**92.00A**	**5.85B**	**7.69A**	**15.66B**	**19.36A**	**38.13B**	**47.63A**	**36.06B**	**37.77A**	**9.26B**	**13.76A**	**3.57B**	**5.99A**

Table 2B: Effect of nitrogen and water stress levels on yield and yield components of cultivar Bhakar-2002

Nitrogen levels (kg ha^{-1})	Plant height (cm)		Spike length (cm)		Spikelets/ spike		Grains/ spike		1000-grain weight (g)		Biological yield (g/ plant)		Grain yield (g/ plant)	
	50%	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**
Control	65.3c	89.0b	5.37c	8.35c	14.7c	17.1c	36.7c	46.0b	33.7d	41.3c	8.2b	11.7c	3.61c	5.44c
50	70.3bc	96.6a	6.53b	9.79b	15.4b	17.9bc	42.0b	48.0a	35.1c	45.4b	12.7a	13.6b	5.04b	6.38b
100	76.3ab	99.6a	8.06a	10.13ab	16.9a	18.8b	44.0a	48.0a	37.4b	47.8a	12.6a	13.3b	5.66a	6.82b
150	78.6a	100.0a	8.20a	10.58a	16.3a	21.0a	44.2a	49.5a	40.5a	47.5a	11.9a	16.9a	4.98ab	8.11a
Means	**72.6B**	**96.3A**	**7.04B**	**9.71A**	**15.8B**	**18.7A**	**41.72B**	**47.87A**	**36.6B**	**45.5A**	**11.35B**	**13.87A**	**4.97B**	**6.68A**

Table 2C: Effect of nitrogen and water stress levels on yield and yield components of cultivar Fareed-2006

Nitrogen levels (kg ha^{-1})	Plant height (cm)		Spike length (cm)		Spikelets/ spike		Grains/ spike		1000 grain weight (g)		Biological yield (g/ plant)		Grain yield (g/ plant)	
	50%	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**
Control	56.87c	81.89b	5.10c	7.37c	13.05b	15.45c	31.50c	37.00c	32.59c	38.83c	5.48c	9.36c	2.37c	4.33c
50	61.72bc	89.65a	6.44b	8.15b	13.75b	16.27b	33.39b	39.17b	34.31b	40.53b	7.00b	10.74b	3.2b	4.77bc
100	67.83ab	92.60a	7.18a	8.40ab	14.87a	17.28a	35.45a	39.53b	35.87a	42.31a	7.95a	11.59ab	3.64ab	5.38b
150	71.56a	92.89a	7.32a	8.65a	14.95a	17.68a	35.78a	41.50a	36.12a	41.77ab	8.19a	13.04a	4.22a	6.05ab
Means	**64.55B**	**89.23A**	**6.51B**	**8.14A**	**14.15B**	**16.67A**	**34.03B**	**39.30A**	**34.72B**	**40.86A**	**7.15B**	**11.18A**	**3.35B**	**5.13A**

Table 2D: Effect of nitrogen and water stress levels on yield and yield components of cultivar Shafaq-2006

Nitrogen levels (kg ha^{-1})	Plant height (cm)		Spike length (cm)		Spikelets/spike		Grains/ spike		1000-grain weight (g)		Biological yield (g/ plant)		Grain yield (g/ plant)	
	50%	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**	**50%**	**100%**
Control	63.52c	86.38c	6.07c	7.70c	14.16c	17.95c	31.75c	41.04d	32.23d	38.89c	8.09c	12.88c	3.74b	5.42d
50	76.91b	92.73b	6.75b	8.32b	16.20b	18.81b	38.25b	47.34c	33.67c	40.08b	9.21b	13.65c	3.85b	6.06c
100	79.30ab	97.27ab	7.12ab	8.70b	16.29b	20.12a	37.75b	46.75b	35.76b	41.47d	9.71b	16.59b	4.34a	7.61b
150	81.00a	102.33a	7.45a	10.35a	17.53a	20.62a	40.75a	51.29a	37.29a	45.43a	11.22a	19.36a	4.79a	8.68a
Mean	**75.18B**	**94.67A**	**6.84B**	**8.76A**	**16.04B**	**19.37A**	**37.125B**	**46.60A**	**34.73B**	**41.46A**	**9.55B**	**15.62A**	**4.18B**	**6.94A**

DISCUSSION

Water deficit conditions slow down the emergence of tested wheat cultivars as compared to control conditions which was depicted by more time to 50% emergence, less energy of emergence and final emergence percentage. Germination phase of wheat is among the most critical and sensitive to water stressed conditions (Ahmad *et al.,* 2009). Slow and poor germination of seeds under water stress conditions is accredited to decreased water potential of the germinating medium (Uniyal and Nautiyal, 1998; Soltani *et al.,* 2002). Osmotic stress due to water deficit conditions can forcefully lead to dormancy state in seeds, caused by restricted water absorption (Singh *et al.,* 1996; Tilki and Dirik, 2007). Seed germination phase of plant is directly linked with the reserve metabolism, energy production, respiration rate and enzymatic and hormonal activities (McDonald, 2007). Water shortage is responsible for various adverse effects at cell and whole plant level. It is of prime importance in solubilization, enzymatic reactions (Ashraf and Foolad, 2005; Besma and Mounir, 2010) and metabolite transportation. It is essential for hydrolytic breakdown of carbohydrate, protein and lipid contents of germinating seeds (Bewley and Black 1994; Biaecka and Ke˛pczyn´ ski 2010). Conversion of endospermic starch into soluble sugars requires the activity of amylase enzyme, during seed germination. This process provides energy to the developing embryo (Nauriere *et al.,* 1992). Water deficit conditions adversely affect the amylase enzyme activity leading to poor germination rate (Kaur *et al.,* 2000; Zeid & Shedeed 2006). It delays the seed germination as depicted by increased time to 50% germination. Nitrogen is an essential macronutrient, which ensures plant growth performance under stressed conditions. In conducted study, it reduced the time to 50% emergence, improved energy of emergence and final emergence percentage, particularly at the rate of 150 kg ha^{-1}. Water deficit conditions reduce the nitrogen absorption by the plant (Nakayama *et al.,* 2007). Nitrogen absorption by plants as nitrates requires water availability for being water soluble. Therefore, prominent response was noted in all the studied parameters with no water stress. Seed germination is reported to be enhanced by nitrites (Hendricks and Taylors, 1974; Roberts and Benjamin, 1979) and applied nitrates are converted to nitrites within the seed resulting in improved seed germination. Water stress at seed germination stage may lead to nitrate reductase inhibition, which can be attributed to poor seed germination. Under stressed conditions, the cultivar shafaq-2006 maintained less time to 50% germination and less MET, more EE and FGP as compared to other tested cultivars, revealing its comparative ability to withstand water stressed conditions, with nitrogen supplementation. It was in confirmation with the findings of Ellis and Roberts, (1981) that seeds with more vigor are reported to have less mean germination time. It can be attributed to its efficient water absorption system with improved protein and carbohydrate metabolism leading to more osmolyte accumulation, which can be related to enhanced water status. The improved osmolyte status of the plant is a defensive mechanism against stressed conditions as it decreases the water potential maintaining turgor with more water absorption by the seed. Nitrogen availability is also directly related with proline accumulation (Sanchez *et al.,* 2007), which is reported to enhance the performance of plant species under drought stress (Chaves *et al.,* 2003). The improved amino acid contents under drought conditions in chickpea (*Cicer arietinum*) was reported by Ashraf and Iram (2005), suggesting more hydrolysis of proteins. Moreover, it has been observed that moderate stress conditions did not impair nitrogen partitioning in common bean (Ramirez-Vallejo and Kelly, 1998) so in current study, it can be assumed that nitrogen supplementation under water stressed conditions supported more efficient nitrogen metabolism with osmolyte accumulation leading to improved physiological and biochemical processes of the seed.

Nitrogen supplementation also leads to improved RWC, yield and yield attributes of tested wheat cultivars under limited water availability. Drought conditions reduce the leaf turgor which is attributed by low RWC and decreased plant water potential (Sen Gupta *et al.,* 1989). This condition might be the reason for reduction in photo-assimilates production which was obvious through less plant height, low yield and yield attributes. Nitrogen fertilization has already been established as stimulant of vital plant biochemical and physiological mechanisms. It is equally important for vegetative and reproductive growth stages of the plant (Brich and Long, 1990). The plant response to nitrogen availability can be seen as genotypic response depending on the extent of root system, enzyme activity, nitrate absorption, assimilate synthesis and soil characteristics as well (Fathi *et al.,* 1997). Nitrogen is also a component of chlorophyll molecule so its availability is directly linked with the process of photosynthesis (Brown, 2000; Shangguan *et al.,* 2000). So, optimized availability of nitrogen leads to more sugar production, enhancing the morphological attributes as well as yield components (spike length, grain/spike, 1000 grain weight, spikelet/spike, biological yield and grain yield) in all tested cultivars, being more obvious at 150 Kg ha^{-1} nitrogen application. The findings are in confirmation with Asif *et al.,* (2012), who reported increment in number of tillers per unit area, number of grains per spike and harvest index with nitrogen application.

***Conclusion*:**

Cultivar Bhakkar-2002 performed better when 100 kg N ha^{-1} was applied at 50% field capacity. Under well watered condition (100% field capacity) maximum performance was recorded in cultivar Shafaq-2006 when 150 kg N ha^{-1} was applied. According to the results of experiment, it is concluded that N applied at rate 100 kg ha^{-1} could ameliorate negative effects of on wheat grown under water stress condition.

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